

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04N	A2	(11) International Publication Number: WO 99/31870 (43) International Publication Date: 24 June 1999 (24.06.99)
(21) International Application Number: PCT/US98/26540 (22) International Filing Date: 14 December 1998 (14.12.98) (30) Priority Data: 08/991,593 15 December 1997 (15.12.97) US (71) Applicant: ANALOG DEVICES, INC. [US/US]; One Technology Way, Norwood, MA 02062 (US). (72) Inventors: BOYD, Stuart, D., J.; 39 Blueberry Lane, Hamilton, MA 01936 (US). QIAN, Dahong; 6 Bolger Lane, Westford, MA 01886 (US). (74) Agents: IANDIORIO, Joseph, S. et al.; Iandiorio & Teska, 260 Bear Hill Road, Waltham, MA 02451 (US).		(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: SPATIALLY OFFSET, ROW INTERPOLATED IMAGE SENSOR (57) Abstract <p>Spatially offset, row interpolated image sensor includes a linear array sensor having a first row of longitudinally extending pixels with a first spatial periodicity and a second row of longitudinally extending pixels having a second spatial periodicity laterally adjacent the first row and longitudinally staggered with respect to the first row; and a read circuit for individually, selectively sampling pixels of the rows for producing a composite output which has a combined spatial periodicity which is shorter than either of the first and second spatial periodicities and has a number of samples equal to the combined samples of both the rows.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the 1

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

SPATIALLY OFFSET, ROW INTERPOLATED IMAGE SENSOR

FIELD OF INVENTION

This invention relates to a spatially offset, row interpolated image sensor.

BACKGROUND OF INVENTION

In conventional line scanners an input page, for example, is read line by line. Each line scanned is collected by a lens and projected into a linear array typically a CCD. The linear array is much smaller than the line, typically 1.0-2.5 inches for a scan line of 8.5 inches. Resolution, an important aspect of any scanner, depends on the number of pixels in the linear array and this in turn depends on the size of the pixels. There is a practical limit to pixel size. In order to improve resolution the pixels are made smaller and smaller. But at some point the pixels become so small that their light collecting ability suffers. The output signal is too small. The pixel size limit is presently believed to be approximately 5μ . The other approach to improve resolution, having reached the minimum pixel size, is to increase the number of pixels by increasing the length of the linear array. Increasing the length of the array enlarges the size of the final component and increases the cost of both the component and the overall system. In present CCD implementations the CCD pixels are not readily compatible with on-chip peripheral circuitry and CCD arrays must be read out sequentially in their entirety.

SUMMARY OF INVENTION

It is therefore an object of this invention to provide an improved linear array image sensor.

It is a further object of this invention to provide such a linear array image sensor with higher resolution.

It is a further object of this invention to provide such a linear array image sensor which is lower in cost.

It is a further object of this invention to provide such a linear array image sensor which doubles the resolution without increasing the length of the array or reducing the pixel size.

It is a further object of this invention to provide such a linear array image sensor which increases resolution without sacrificing light collection ability or increasing system cost.

It is a further object of this invention to provide such a linear array image sensor which is implementable in CMOS making it more compatible with on-chip peripheral circuitry.

It is a further object of this invention to provide such a linear array image sensor which unlike conventional CCD implemented linear arrays can have its pixels read out individually, selectively.

It is a further object of this invention to provide such a linear array image sensor in which lower resolution images can be read out in much less time.

The invention results from the realization that a spatially offset, row interpolated image sensor capable of much higher resolution without increasing the length of the linear array can be effected by arranging the pixels of the array in at least two adjacent longitudinal rows with the pixels in each row staggered longitudinally with respect to those in the adjacent row and sampling pixels from each row so the apparent periodicity is shorter than the periodicities of any of the individual rows resulting in the output of the linear array having a total number of samples equal to that of all the rows combined.

This invention features as partially offset, row interpolated image sensor. There is a linear array sensor including a first row of longitudinally extending pixels having a first spatial periodicity and a second row of longitudinally extending pixels having a second spatial periodicity laterally adjacent the first row and longitudinally staggered with respect to the first row. A read circuit individually, selectively samples the pixels of the rows and produces a composite output which has a combined spatial periodicity which is shorter than either of the first and second spatial periodicities and has a number of samples equal to the combined samples of both the rows.

In a preferred embodiment the first and second periodicities may be the same. The rows of pixels may be offset laterally by approximately one half the first periodicity. The linear array sensor and the read circuit may be on the same chip. The linear array sensor and the read circuit may be CMOS implemented. The read circuit may sample the pixels of the first row interleaved with those of the second row.

DISCLOSURE OF PREFERRED EMBODIMENT

Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a line scanner employing the spatially offset, row interpolated image sensor according to this invention;

Fig. 2 is a schematic diagram showing in greater detail the image sensor of Fig. 1;

Fig. 3 illustrates a number of signals occurring in the operation of the image sensor of Fig. 2;

Fig. 4 is a more detailed illustration of the read circuit of Fig. 2;

Fig. 5 is a schematic diagram illustrating an alternative arrangement for sampling and combining pixels from different rows; and

Fig. 6 is a block diagram showing the image sensor of this invention in a three color application.

There is shown in Fig. 1 a schematic diagram of a portion of a scanner 10 employing the spatially offset, row interpolated image sensor 12 according to this invention. The object or paper being scanned 14 is moved relative to the image sensor 12. Here it is the paper 14 that is being moved in the direction of arrow 16. Image sensor 12 includes the linear array 18 and the read circuit 19 which includes control timing circuit 20, sampling circuit 21 and MUX 22. All three components of read circuit 19 may be on the same chip which may be a CMOS chip 23 and may be integral with chip 25 containing linear array 18. The image is projected from the page or paper 14 to the linear array 18 which is managed by control timing circuit 20 to provide an output through MUX 22 a line at a time as paper 14 and linear array 18 are moved relative to one another.

Linear array 18, Fig. 2, includes first and second rows 30, 32 which are adjacent to one another and formed of a plurality of longitudinally extending pixels 34, 36. Typically pixels 34 in row 30 have a spatial periodicity or pitch W_1 . Pixels 36 in row 32 have a periodicity or pitch of W_2 . Typically the pitch is equivalent to the width of the pixels. For example, with a high resolution system employing eight micron wide pixels, W_1 would be 8 microns. Typically, but not necessarily, W_2 is equal to W_1 .

so it too could have a pitch of 8 microns. It is noted that fabrication tolerances in manufacturing scanner 10 result in variations of the lateral separation of the pixels. The position of centroids of sensitivity 35 of pixels 34 and 36 in rows 30 and 32 can vary laterally as much as one half of the periodicity or pitch W_1 of the cells in the longitudinal direction as indicated by the $W_1/2$ dimension 37. Thus if the lateral spacing can be kept within that range, the two rows effectively function as one row. Yet because the two rows are staggered with respect to one another they can be sampled so that they provide a periodicity which is shorter than either W_1 or W_2 . If W_1 and W_2 are equal then the periodicity overall of the combined rows 30 and 32 can be as little as $W_1/2$. Thus while the overall length of linear array 18 typically provides a resolution afforded by the periodicity W_1 , with this invention the same length row can provide a resolution of twice that, a resolution normally associated with a linear sensor twice as long. Read circuit 20 includes a first plurality of switches 42, the odd switches which read out pixels 34 in row 30 at times $t_1, t_3, t_5, t_7, t_9, \dots$. Second switch circuit 44 reads out pixels 36 in row 32 at even times $t_2, t_4, t_6, t_8, \dots$. Typically but not necessarily, the switches can be read out alternately odd and even: first t_1 , then t_2 , then t_3 , then t_4 , then t_5, \dots . If switch 22a then operated synchronously with switches 42 and 44, a single line of interleaved outputs from pixels 34 and 36 can be obtained whereby the signal is a combined series of pixels alternating from rows 30 and 32, at times $t_1, t_2, t_3, t_4, t_5, \dots$.

In operation, switch control signal 50 operates alternately with switch control signal 52 to control switches 42 and 44. This results in the output at point A from the first row 42 appearing as at 54, Fig. 3, and the output at point D from second row 44 appearing as at 56. The amplitudes of the signals 54 and 56 differ since the amount of incident light on each pixel may differ. The phase of signals 54 and 56, however, are shown as being at 180° since there are but two rows 30 and 32 and they are oppositely phased. The combined output then, with the pixels of the two rows 30, 32 interleaved, appears at C as shown by signal 58 where the two signals A and B are interleaved so that the final signal has a length of both the outputs A and B combined with a periodicity that is one half of either and provides a resolution of, for example, 600 dpi. An added advantage of this invention is that if a lower resolution is acceptable, e.g., 300 dpi, the system can be made to read out only one row in half the time, or for 200 dpi in a third

of the time. This is so because the system can be implemented in CMOS which permits individual selection of pixels unlike CCD implementation.

In one embodiment switches 42 and 44 are replaced by shift registers 42b and 44b associated with rows 30b and 32b, respectively, of linear array sensor 18b, Fig. 4. Control timing circuit 20b provides a control pulse and a clock pulse to each of shift registers 42b and 44b. In each case the control pulse selects the stage of the shift register or the particular pixel 34b, 36b which is to be sampled, and then the sample is actually taken upon the occurrence of the clock signal. In this way the contents of the pixels 34b, 36b may be sampled and read out in any order: all the pixels in row 30b, then all the pixels in row 32b, or one from each row, or two from each row, or two from one and one from the other, whatever is desired. Once the output from a particular cell has been collected and clocked out, multiplexer 22b is synchronized by the clock pulse from control timing circuit 20b to select the output of the appropriate register 42b, 44b from which to receive that sample and provide the output.

Although the representations in Figs. 1-4 illustrate a sampling which is interleaved between the two rows and a sampling which takes place directly from the pixels in each row, these are not necessary limitations of the invention. For example, as shown in Fig. 5, the contents of pixels 34c in row 30c may be read out serially in their entirety to a temporary line storage 60. Similarly, the contents of pixels 36c of row 32c may be read out serially in their entirety to line storage 62. After, they may be combined in any desired combination under control of a microprocessor or other control device. For example, they may be combined in the heretofore explained interleaved one by one combination as shown at 64, or they may be combined in any other desired form.

Although the invention has been explained in terms of a single linear array sensor, more typically three such devices are used in color systems, one for red, one for green and one for blue. In such a case, three linear arrays 18d, 18e, 18f, Fig. 6, associated with sampling circuits 21d, 21e, 21f are operated by control timing circuit 20d to provide the multiplexed outputs to MUX 22d which multiplexes not two but six signals to provide the red, green and blue signals in accordance with the spatially offset row interpolated image sensor according to this invention.

Although specific features of this invention are shown in some drawings and not

others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention.

Other embodiments will occur to those skilled in the art and are within the following claims:

What is claimed is:

CLAIMS

1 1. A spatially offset, row interpolated image sensor comprising:
2 a linear array sensor including a first row of longitudinally
3 extending pixels having a first spatial periodicity and a second row of longitudinally
4 extending pixels having a second spatial periodicity laterally adjacent said first row and
5 longitudinally staggered with respect to the first row; and a read circuit for individually,
6 selectively sampling pixels of said rows for producing a composite output which has a
7 combined spatial periodicity which is shorter than either of the first and second spatial
8 periodicities and has a number of samples equal to the combined samples of both the
9 rows.

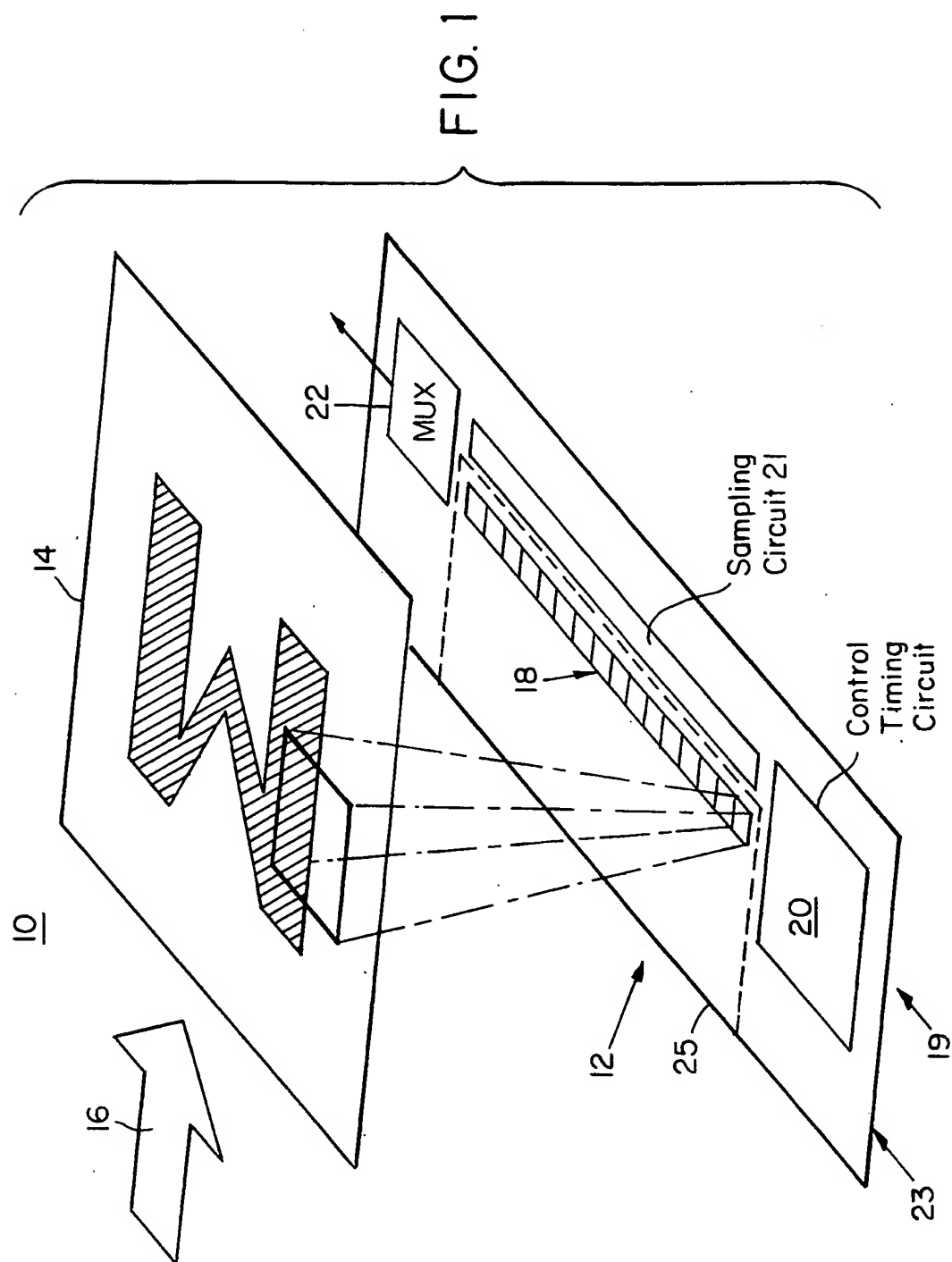
1 2. The spatially offset, row interpolated image sensor of claim 1 in
2 which the first and said periodicities are the same.

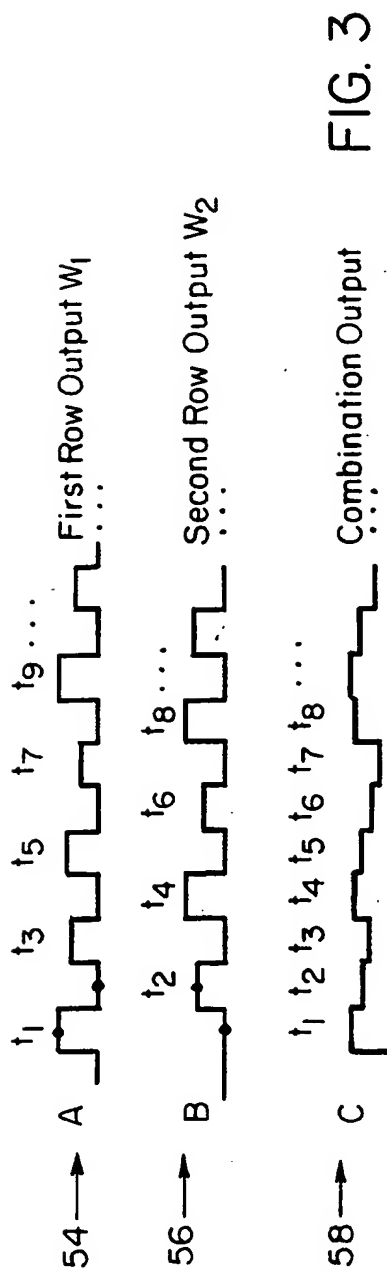
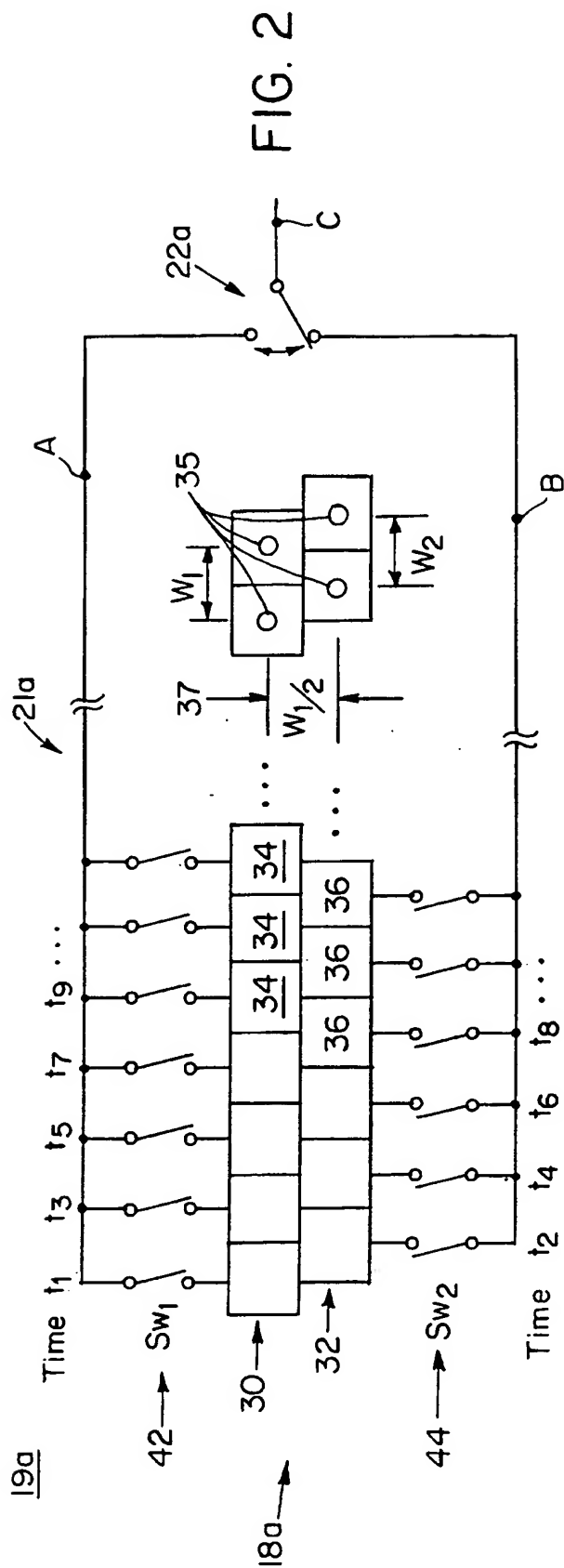
1 3. The spatially offset, row interpolated image sensor of claim 1 in
2 which the first and second rows of pixels are offset laterally by approximately one half
3 the first periodicity.

1 4. The spatially offset, row interpolated image sensor of claim 1 in
2 which said linear array sensor and said read circuit are on the same chip.

1 5. The spatially offset, row interpolated image sensor of claim 1 in
2 which said linear array sensor and said read circuit are CMOS implemented.

1 6. The spatially offset, row interpolated image sensor of claim 1 in
2 which said read circuit samples the pixels of the first row interleaved with those of the
3 second row.





3/4

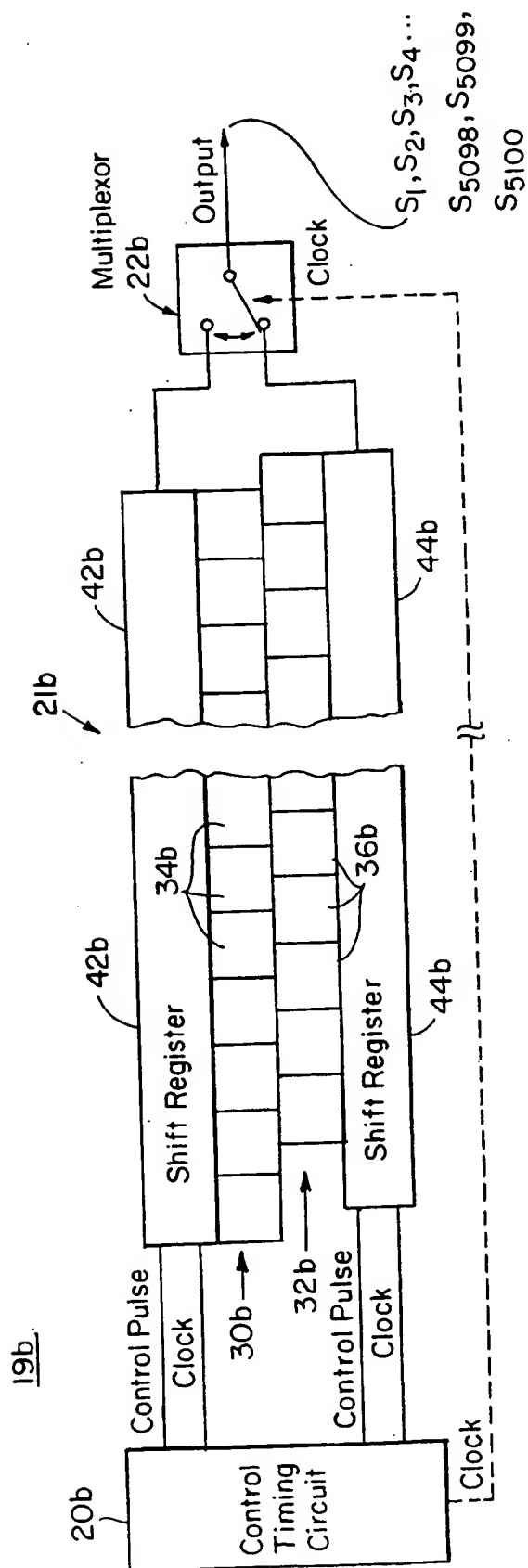


FIG. 4

4/4

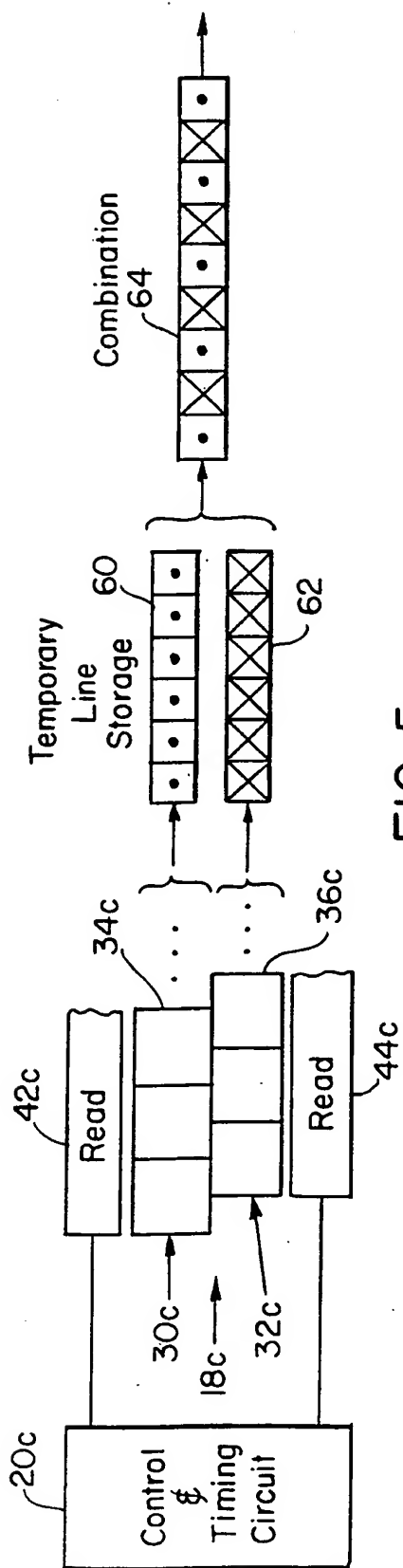


FIG. 5

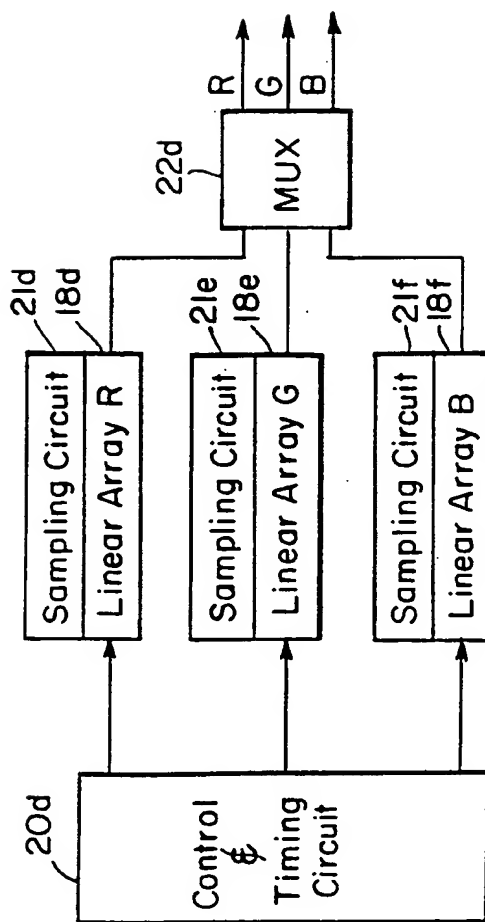


FIG. 6



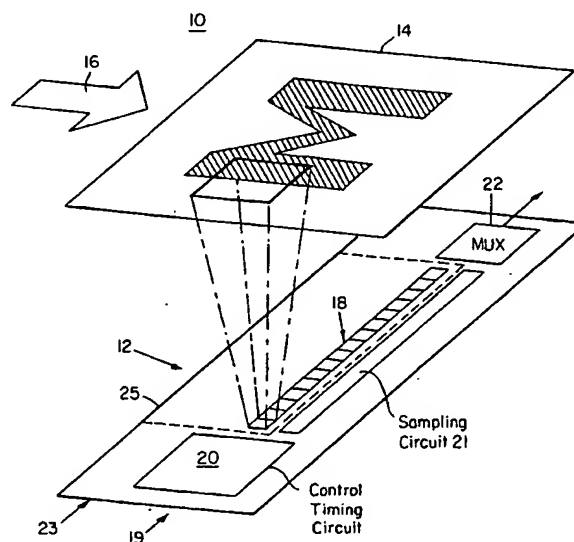
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04N 1/04	A3	(11) International Publication Number: WO 99/31870 (43) International Publication Date: 24 June 1999 (24.06.99)
(21) International Application Number: PCT/US98/26540 (22) International Filing Date: 14 December 1998 (14.12.98) (30) Priority Data: 08/991,593 15 December 1997 (15.12.97) US (71) Applicant: ANALOG DEVICES, INC. [US/US]; One Technology Way, Norwood, MA 02062 (US). (72) Inventors: BOYD, Stuart, D., J.; 39 Blueberry Lane, Hamilton, MA 01936 (US). QIAN, Dahong; 6 Bolger Lane, Westford, MA 01886 (US). (74) Agents: IANDIORIO, Joseph, S. et al.; Iandiorio & Teska, 260 Bear Hill Road, Waltham, MA 02451 (US).	(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> (88) Date of publication of the international search report: 10 September 1999 (10.09.99)	

(54) Title: SPATIALLY OFFSET, ROW INTERPOLATED IMAGE SENSOR

(57) Abstract

A spatially offset, row interpolated image sensor includes a linear array sensor (18) having a first row (30) of longitudinally extending pixels with a first spatial periodicity (W1) and a second row (32) of longitudinally extending pixels having a second spatial periodicity (W2) laterally adjacent the first row (30) and longitudinally staggered with respect to the first row (30); and a read circuit (19) for individually, selectively sampling pixels of the rows (30, 32) for producing a composite output which has a combined spatial periodicity which is shorter than either of the first and second spatial periodicities (W1, W2) and has a number of samples equal to the combined samples of both the rows (30, 32).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/26540

A. CLASSIFICATION OF SUBJECT MATTER														
IPC(6) : H04N 1/04														
US CL : Please See Extra Sheet.														
According to International Patent Classification (IPC) or to both national classification and IPC														
B. FIELDS SEARCHED														
Minimum documentation searched (classification system followed by classification symbols)														
U.S. : 358/482, 483, 474, 445, 514; 382/312; 250/208.1; 348/364, 275, 307														
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched														
None														
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)														
APS search terms: interleave, interpolated, alternate, odd, even, sensors, rows, CMOS, switches														
C. DOCUMENTS CONSIDERED TO BE RELEVANT														
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.												
Y	US 4,558,365 A (OCHI et al.) 10 December 1985, Figs. 1-3, col. 4, lines 35-58	1-6												
Y	US 5,262,871 A (WILDER et al.) 16, November 1993, col. 17, lines 20-25, col. 18, line 35 to col. 19, line 15, Figs. 11B-11D	1, 5												
Y	US 5,264,694 A (DIEHL et al.) 23, November 1993, Figs. 2A-3, col. 3, line 20 to col. 4, lines 17	1-6												
Y,P	US 5,751,444 A (WARD) 12 May 1998, Fig. 7, col. 9, lines 20-39	1-6												
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.														
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>*A* document defining the general state of the art which is not considered to be of particular relevance</td> <td>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>*E* earlier document published on or after the international filing date</td> <td>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>*G* document member of the same patent family</td> </tr> <tr> <td>document referring to an oral disclosure, use, exhibition or other means</td> <td></td> </tr> <tr> <td>*P* document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family	document referring to an oral disclosure, use, exhibition or other means		*P* document published prior to the international filing date but later than the priority date claimed	
* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention													
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone													
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art													
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family													
document referring to an oral disclosure, use, exhibition or other means														
P document published prior to the international filing date but later than the priority date claimed														
Date of the actual completion of the international search		Date of mailing of the international search report												
14 MARCH 1999		16 JUL 1999												
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer CHEUKFAN LEE <i>James R. Matthews</i> Telephone No. (703) 305-4867												

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/26540

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

358/482, 483, 474, 445, 514; 382/312; 250/208.1; 348/364, 275, 307